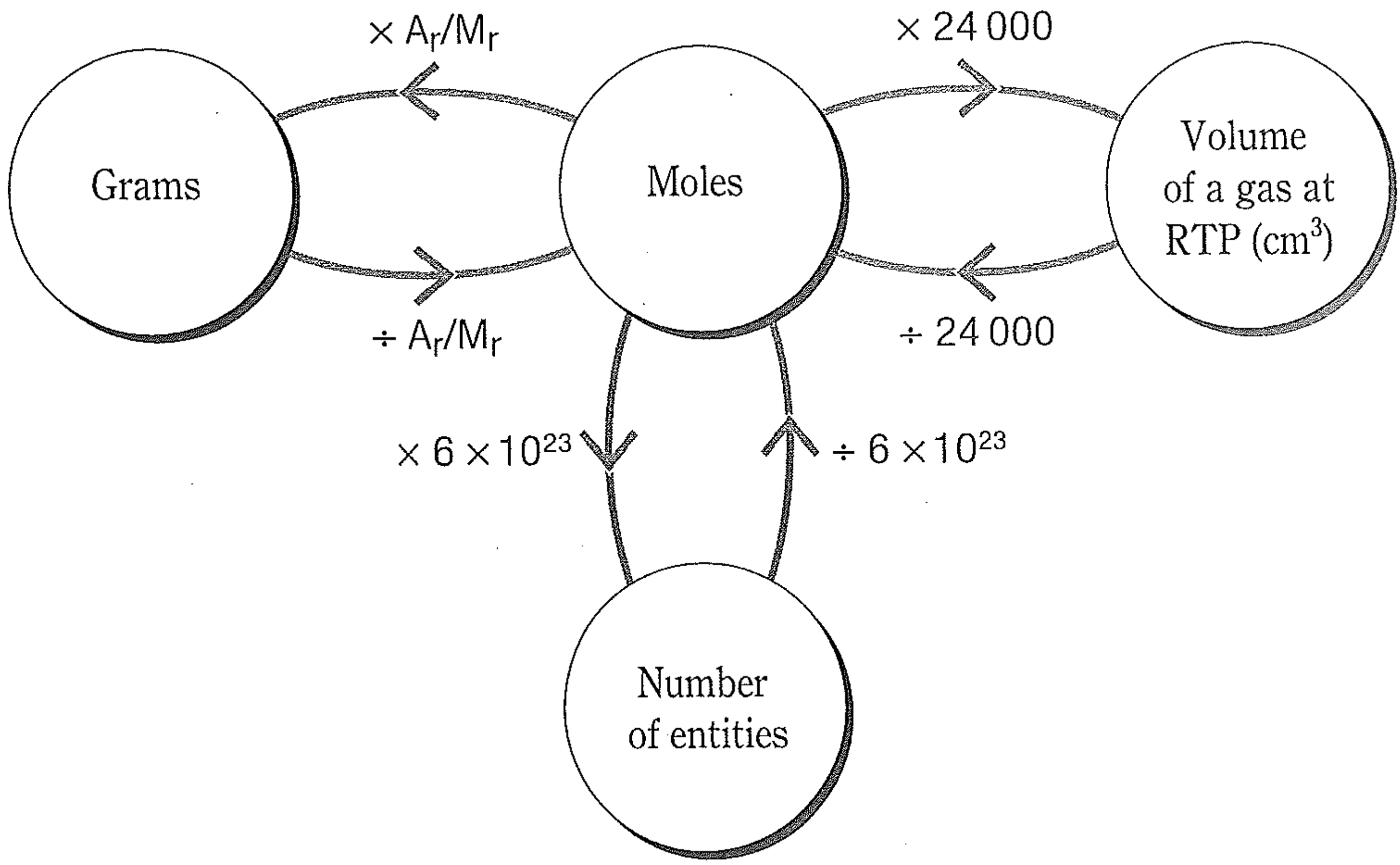
Moles summary



Calculating empirical and molecular formulae

e.g. Calculate the empirical formula of a compound with the following composition: 52.1% carbon, 13% hydrogen, 34.9% oxygen. Given that its relative molecular mass is 92, calculate its molecular formula.

Answer

List the elements in columns, with their percentage by mass underneath, then follow these stages:

	C		H		O
% by mass	52.1		13.0		34.9
Moles (÷ A_r)	$\frac{52.1}{12}$		$\frac{13.0}{1}$		$\frac{34.9}{16}$
=	4.34		13.0		2.18
Divide through by the smallest number (2.18)	1.99 ≈ 2	:	5.96 ≈ 6	:	1

∴ Empirical formula: C_2H_6O ($M_r = 46$)
M_r for the compound: $46 \times 2 = 92$
∴ Molecular formula: $2 \times C_2H_6O = C_4H_{12}O_2$

The use of moles in equations

e.g. Calculate the mass of water produced when 20 g of ammonium dichromate(VI) decomposes according to the following equation:

$$(NH_4)_2Cr_2O_7 \rightarrow Cr_2O_3 + 4H_2O + N_2$$

Answer

Work in the following steps:

Step 1 Convert the grams into moles

$$20 \text{ g of } (NH_4)_2Cr_2O_7 = \frac{20}{252} = 0.079 \text{ mol}$$

Step 2 This is the only step where you can use the molar ratios in the equation

1 mol $(NH_4)_2Cr_2O_7$ produces 4 mol H_2O

$\therefore$ 0.079 mol $(NH_4)_2Cr_2O_7$ produces $4 \times 0.079 = 0.317$ mol H_2O

Step 3 Convert the moles back to grams

$$0.317 \text{ mol } H_2O = 0.317 \times 18 \text{ g} = \mathbf{5.71} \text{ g } H_2O$$

Grams ⟷ moles and the Avogadro constant (1)

1 How many moles of molecules are there in:
(a) 4 g of methane, CH_4
(b) 6.4 g of sulphur dioxide, SO_2
(c) 2.8 g of nitrogen, N_2
(d) 190 g of fluorine, F_2
(e) 56 g of carbon monoxide, CO

2 What is the mass of:
(a) 0.02 mol of octane, C_8H_{18}
(b) 5 mol of zinc atoms
(c) 0.25 mol of calcium chloride, $CaCl_2$
(d) 2 mol of chlorine molecules, Cl_2
(e) 0.125 mol of carbonate ions, CO_3^{2-}

3 How many moles of:
(a) molecules are there in 4.6 g of nitrogen dioxide, NO_2
(b) nitrate ions are there in 66.2 g of lead nitrate, $Pb(NO_3)_2$
(c) atoms are there in 14 g of krypton, Kr
(d) molecules are there in 7 g of carbon monoxide, CO
(e) sulphate ions are there in 6.84 g of aluminium sulphate, $Al_2(SO_4)_3$

4 What is the mass of:
(a) 0.1 mol of calcium oxide, CaO
(b) 3 mol of water, H_2O
(c) 0.25 mol of potassium manganate(VII), $KMnO_4$
(d) 1.2 mol of lead(II) phosphate, $Pb_3(PO_4)_2$
(e) 10 mol of sodium chloride, NaCl

5
(a) What mass of magnesium chloride ($MgCl_2$) must be taken if it is to contain 10.65 g of chloride ions?
(b) What mass of aluminium nitrate ($Al(NO_3)_3$) should be taken if it is to contain 3.93 g of nitrate ions?
(c) A sample of hydrated copper sulphate, $CuSO_4.5H_2O$, weighs 50 g. How many moles of water molecules does it contain?

6 Write down:
(a) The mass of zinc with the same number of atoms as there are hydroxide ions in 12.2 g of magnesium hydroxide, $Mg(OH)_2$.
(b) The mass of iron which has the same number of atoms as there are nitrate ions in 0.36 g of silver nitrate, $AgNO_3$.
(c) The mass of sulphur dioxide which contains the same number of molecules as there are in 38 g of carbon dioxide, CO_2.
(d) The mass of water which contains the same number of molecules as there are chloride ions in 24.2 g of calcium chloride, $CaCl_2$.

7 How many grams of sulphur contain:
(a) 3×10^{23} atoms
(b) 12×10^{23} atoms
(c) 12×10^{14} atoms

8 What is the mass of:
(a) 2 molecules of nitrogen dioxide, N_2O_4
(b) 4 molecules of water, H_2O
(c) 1 molecule of sulphur dioxide, SO_2

9 In a Ministry of Transport test, a bus is found to release 6.7 g of carbon monoxide gas (CO(g)) every mile driven. How many molecules of CO(g) is this every mile?

10 Approximately 150 million tonnes of sulphur dioxide ($SO_2(g)$) are emitted from the burning of oil and coal throughout the world each year. How many SO_2 molecules are emitted per second?

Percentage composition, empirical and molecular formulae ②

1 Calculate the percentage by mass of:
(a) Carbon in carbon dioxide
(b) Hydrogen in pentane, C_5H_{12}
(c) Oxygen in chromium nitrate, $Cr(NO_3)_3$

2 Calculate the percentage of sulphur in the following compounds:
(a) Sulphuric acid, H_2SO_4
(b) Sulphur trioxide, SO_3
(c) Hydrogen sulphide, H_2S
(d) Sodium thiosulphate, $Na_2S_2O_3$
(e) Hydrated copper sulphate crystals, $CuSO_4.5H_2O$

3 A farmer buys a bag of fertiliser which is a mixture of ammonium sulphate ($(NH_4)_2SO_4$) and potassium nitrate (KNO_3). The bag weighs 20 kg and 30% of this mass is ammonium sulphate. Calculate the total mass of nitrogen in the bag of fertiliser.

4 Work out the empirical formulae of:
(a) An oxide of nitrogen in which 8.4 g of nitrogen combines with 4.8 g of oxygen.
(b) Iron chloride, if 0.86 g of iron reacts with 1.64 g of chlorine.
(c) Silicon oxide, if 5.36 g of the oxide contains 2.50 g of silicon.

5 What is the empirical formula of:
(a) An acid which contains 22.4% nitrogen, 76.0% oxygen and 1.6% hydrogen.
(b) An alcohol which contains 52.2% carbon, 13.0% hydrogen and 34.8% oxygen.
(c) An organic compound with the analysis 62.1% carbon, 27.6% oxygen, 10.3% hydrogen.

6 An organic acid contains 0.848 g of carbon, 0.14 g of hydrogen and 1.13 g of oxygen. Given that the relative molecular mass of the compound is 60, calculate the empirical and molecular formulae of the compound and suggest a possible structure.

7 The metal nickel combines with carbon monoxide to form the compound nickel carbonyl, Ni(CO)x. When 2.95 g of nickel was warmed gently in carbon monoxide, it was converted completely into 8.55 g of nickel carbonyl. Find the mass of carbon monoxide which had combined with the 2.95 g of nickel and then deduce the value of x in the formula.

8 Crystals of hydrated iron(II) sulphate, $FeSO_4.xH_2O$, contain 54.68% of iron sulphate, the remainder being water. Calculate the value of x from this information. Using this value of x, find the relative formula mass of the compound. When left in air for some time, 15.8 g of the crystals were found to lose 5.11 g of water and form crystals which have the formula $FeSO_4.yH_2O$. Calculate the value of y.

Grams ⟷ moles in equations

(3)

1 Calcium carbide (CaC_2) reacts with water to produce ethyne (C_2H_2) according to the following equation:

$$CaC_2(s) + 2H_2O(l) \longrightarrow Ca(OH)_2(aq) + C_2H_2(g)$$

If 3.2 g of calcium carbide are reacted with an excess of water, what mass of ethyne gas will be produced?

2 Calcium carbide is manufactured according to the following equation:

$$CaO(s) + 3C(s) \longrightarrow CaC_2(s) + CO(g)$$

If 20 g of CaC_2 are required, what mass of carbon must be reacted?

3 In the thermite process for on-the-spot welding of steel, iron oxide is reduced by aluminium to produce aluminium oxide and iron with the evolution of much heat.

$$8Al(s) + 3Fe_3O_4(s) \longrightarrow 4Al_2O_3(s) + 9Fe(s)$$

Write an expression for the mass of iron oxide which will react completely with x g of aluminium.

4 One stage in the production of chromium metal from its ore chromite, $Fe(CrO_2)_2$, is as follows:

$$4Fe(CrO_2)_2(s) + 8Na_2CO_3(s) + 7O_2(g) \longrightarrow 8Na_2CrO_4(s) + 2Fe_2O_3(s) + 8CO_2(g)$$

If 11.2 kg of chromite are reacted:
(a) What mass of sodium chromate (Na_2CrO_4) would be produced?
(b) What mass of oxygen gas would be needed to react exactly?

5 Gaseous ammonia reacts with heated copper(II) oxide according to the equation:

$$3CuO(s) + 2NH_3(g) \longrightarrow 3Cu(s) + N_2(g) + 3H_2O(l)$$

In an experiment, 3.4 g of ammonia is reacted with heated copper oxide, calculate:
(a) The mass of copper formed;
(b) The mass of nitrogen gas produced.

6 The industrial production of nitric acid involves the following stages:

$$4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(g)$$

$$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$$

$$3NO_2(g) + H_2O(l) \longrightarrow 2HNO_3(aq) + NO(g)$$

If 1.7 tonnes of ammonia are reacted with excess oxygen in the first stage, what mass of nitric acid will be produced assuming that each stage of the reaction has a 100% yield?

7 One technique for reducing the emission of nitrogen monoxide from car exhausts is to react it with ammonia gas, according to the following equation:

$$4NH_3(g) + 6NO(g) \longrightarrow 5N_2(g) + 6H_2O(g)$$

If a car emits 0.4 g of nitrogen monoxide per mile, what mass of ammonia will be required to neutralise it per day, if the car travels 12 000 miles per year?

8 Some iron metal was burned in chlorine gas to form solid iron chloride. It was found that 4.2 g of iron reacted exactly with 7.99 g of chlorine. Deduce the equation for the reaction.

9 In an experiment, it is found that 3.2 g of copper metal reacts exactly with 8.4 g of nitric acid (HNO_3).
(a) Calculate the moles of copper and nitric acid that reacted.
(b) Hence calculate the molar ratio in which copper and nitric acid react.
(c) Given that the products of the reaction are copper nitrate ($Cu(NO_3)_2$), nitrogen monoxide (NO) and water, deduce the equation for the reaction.

10 An organic preparation of N-propylethanamide involves the reaction between ethanoyl chloride (CH_3COCl) and propylamine ($C_3H_7NH_2$):

$$CH_3COCl + C_3H_7NH_2 \longrightarrow CH_3CONHC_3H_7 + HCl$$

3.14 g of ethanoyl chloride are reacted with an excess of propylamine and 3.21 g of N-propylethanamide are produced. What is the percentage yield of the product?

Gaseous moles (4)

1 How many moles of gas are there, at room temperature and pressure, in:
- (a) 48 000 cm^3 of carbon dioxide
- (b) 120 cm^3 of sulphur dioxide
- (c) 4.8 dm^3 of ammonia

2 What volume will the following quantities of gas occupy at room temperature and pressure?
- (a) 5 mol of nitrogen dioxide
- (b) 3×10^{-3} mol of hydrogen sulphide
- (c) 0.1 mol of argon

3 Convert the following masses of gases into volumes at standard temperature and pressure:
- (a) 1×10^{-4} g of methane, CH_4
- (b) 0.11 g of carbon dioxide, CO_2
- (c) 1 g of hydrogen, H_2

4 Calculate the volume of hydrogen evolved at RTP when 3.25 g of zinc are added to an excess of hydrochloric acid:

$$Zn(s) + 2HCl(aq) \longrightarrow ZnCl_2(aq) + H_2$$

5 What volume of nitrogen dioxide is evolved at RTP when 18.5 g of magnesium nitrate are fully decomposed by heat?

$$2Mg(NO_3)_2(s) \longrightarrow 2MgO(s) + 4NO_2(g) + O_2(g)$$

6 What volume of oxygen is needed at RTP to react with 10 dm^3 of pentane gas when it burns and what volume of carbon dioxide will be formed?

$$C_5H_{12}(g) + 8O_2(g) \longrightarrow 5CO_2(g) + 6H_2O(l)$$

7 250 cm^3 of SO_2 and 300 cm^3 of H_2S reacted together according to the following equation:

$$SO_2(g) + 2H_2S(g) \longrightarrow 2H_2O(g) + 3S(s)$$

What volume of gas will be left at the end of the reaction?

8 10 cm^3 of a hydrocarbon of formula C_xH_y were burnt in excess oxygen. At the end of the reaction 0.048 g of liquid water had been formed and the total volume of gas left was 80 cm^3, of which 30 cm^3 was unburnt oxygen. Deduce the values of x and y in the formula of the hydrocarbon. All measurements were taken at STP.

Moles in solution (5)

1 What is the concentration (in mol dm^{-3}) of the following solutions:

(a) 0.5 mol of potassium iodide dissolved in 125 cm^3 of water
(b) 1 mol of sodium chloride dissolved in 2 dm^3 of water
(c) 1.25×10^{-3} mol of ammonium nitrate dissolved in 75 cm^3 of water

2 How many moles are in the following:

(a) 30 cm^3 of a 0.2 M solution of hydrochloric acid
(b) 120 cm^3 of a 2.4 M solution of potassium nitrate
(c) 2 dm^3 of a 0.9 M solution of magnesium sulphate

3 How many grams of the named substance will be present in:

(a) 50 cm^3 of 2.0 M sulphuric acid, H_2SO_4
(b) 250 cm^3 of 0.25 M barium chloride, $BaCl_2$
(c) 2 dm^3 of 0.75 M potassium carbonate, K_2CO_3

4 In a titration, 25 cm^3 of 0.1 M potassium hydroxide is pipetted into a conical flask. Sulphuric acid is run in from the burette and it was found that 19.8 cm^3 were required to react exactly. Calculate the concentration of a solution of sulphuric acid.

$$H_2SO_4(aq) + 2KOH(aq) \longrightarrow K_2SO_4(aq) + 2H_2O(l)$$

5 Excess calcium carbonate is added to 20 cm^3 of 1.2 M nitric acid. Calculate the volume of carbon dioxide formed at room temperature and pressure.

$$CaCO_3(s) + 2HNO_3(aq) \longrightarrow Ca(NO_3)_2(aq) + H_2O(l) + CO_2(g)$$

6 Calculate the mass of silver chloride that will be precipitated when 10 cm^3 of 1.5 M magnesium chloride are added to an excess of silver nitrate solution.

$$2AgNO_3(aq) + MgCl_2(aq) \longrightarrow 2AgCl(s) + Mg(NO_3)_2(aq)$$

7 17.16 g of hydrated sodium carbonate of formula $Na_2CO_3.xH_2O$ were dissolved in water and made up to exactly 250 cm^3 in a standard flask. 25 cm^3 of this solution were then pipetted into a conical flask and titrated with 0.78 M hydrochloric acid; 15.4 cm^3 were required. Calculate the value of x in the formula.

$$Na_2CO_3.xH_2O(s) + 2HCl(aq) \longrightarrow 2NaCl(aq) + CO_2(g) + (x+1)H_2O(l)$$

8 Manganate(VII) ions react in acid solution with hydrogen peroxide according to the following equation:

$$2MnO_4^-(aq) + 5H_2O_2(aq) + 6H^+(aq) \longrightarrow 2Mn^{2+}(aq) + 5O_2(g) + 8H_2O(l)$$

(a) Calculate the volume of potassium manganate(VII) of concentration 0.04 mol dm^{-3} required to react with 40 cm^3 of 0.01 mol dm^{-3} hydrogen peroxide.
(b) What volume of oxygen gas will be given off at RTP?

The ideal gas equation

(6)

These questions will only be required for some AS/A2 specifications.

Assume that 1 atmosphere = 100 kPa = 1.0×10^5 N m^{-2}.

1 What would be the volume of a gas at STP if it occupied:

(a) 240 cm^3 at 80°C and 70 kPa
(b) 18 dm^3 at –13°C and 2 atmospheres pressure
(c) 33 dm^3 at 56°C and 200 kPa
(d) 85 dm^3 at 0°C and 2 MPa

2 How many moles are there in:

(a) 4.4 dm^3 of carbon dioxide at 20°C and atmospheric pressure
(b) 16 dm^3 of sulphur dioxide at 0°C and 129 kPa
(c) 22 g of carbon dioxide at 60°C and 50 kPa

3 (a) What is the volume of two moles of oxygen at room conditions (20°C and atmospheric pressure)?
(b) What will be the pressure of a gas, three moles of which occupy 48 dm^3 at 25°C?
(c) If six moles of gas are heated at 100 kPa pressure so the volume is 180 dm^3, what is the temperature?
(d) What is the volume, at 18°C and 3.5 MPa, of 32 g of sulphur dioxide?

4 A 2.0 dm^3 vessel contains 3.4 g of H_2S at a pressure of y MPa and a 5.0 dm^3 vessel contains 17 g of NH_3 at the same temperature. What is the pressure of the NH_3?

5 A gas sample, whose relative molecular mass is 153, occupies 1550 cm^3 at STP. What is the mass of the gas sample?

6 3.00 g of a gas at 91°C and 0.125 MPa pressure occupies 1600 cm^3. Calculate the relative molecular mass of the gas?

7 Calculate the volume occupied by 8.00 g of pure sulphur trioxide gas at 1.0×10^5 N m^{-2} pressure and 546 K.

8 Calculate the number of moles of an ideal gas that occupies 2.90×10^3 cm^3 at 3.50×10^5 N m^{-2} and 320 K.

9 A gaseous hydrocarbon has a density of 1.459 g dm^{-3} at 320 K and 1.30×10^5 N m^{-2} pressure. Calculate its relative molecular mass.

10 0.80 g of a gas was placed into a vessel of volume 0.95 dm^3 at a temperature of 240°C. The gas was found to exert a pressure of 0.55 atmospheres. Calculate the relative molecular mass of the gas.

Answers

Sheet 1

1 (a) 0.25 mol (b) 0.1 mol (c) 0.1 mol (d) 5 mol (e) 2 mol
2 (a) 2.28 g (b) 325 g (c) 27.75 g (d) 142 g (e) 7.5 g
3 (a) 0.1 mol (b) 0.4 mol (c) 0.167 mol (d) 0.25 mol (e) 0.06 mol
4 (a) 5.6 g (b) 54 g (c) 39.5 g (d) 973 g (e) 585 g
5 (a) 14.25 g (b) 4.5 g (c) 1 mol
6 (a) 27.3 g (b) 0.118 g (c) 55.3 g (d) 7.85 g
7 (a) 16 g (b) 64 g (c) 6.4×10^{-8} g
8 (a) 1.53×10^{-22} g (b) 1.20×10^{-22} g (c) 1.07×10^{-22} g
9 1.44×10^{23} molecules
10 4.46×10^{22} molecules

Sheet 2

1 (a) 27.3% (b) 16.7% (c) 60.5%
2 (a) 32.7% (b) 40% (c) 94.1% (d) 40.5% (e) 12.8%
3 Relative formula masses: $(NH_4)_2SO_4$ = 132, KNO_3 = 101
Mass in the bag due to ammonium sulphate = 20 × 30/100 = 6 kg
Mass of N from ammonium sulphate = 28/132 × 6 = 1.27 kg
Mass in the bag due to potassium nitrate = 20 – 6 = 14 kg
Mass of N from potassium nitrate = 14/101 × 14 = 1.94 kg
Therefore total mass of nitrogen in the bag = 3.21 kg
4 (a) N_2O (b) $FeCl_3$ (c) SiO_2
5 (a) HNO_3 (b) C_2H_6O (c) C_3H_6O
6 Empirical formula = CH_2O Molecular formula = $C_2H_4O_2$
Possible structure: as for ethanoic acid
7 Mass of carbon monoxide combined with the 2.95 g of nickel = 8.55 – 2.95 = 5.60 g
Moles of Ni in 2.95 g = 2.95/59 = 0.05 mol
Moles of CO in 5.60 g = 5.60/28 = 0.2 mol
Molar ratio Ni:CO = 0.05:0.2, i.e. 1:4
Therefore x = 4
8 $FeSO_4$ = 152, H_2O = 18
Therefore 152 × 100/(152 + 18x) = 54.68
x = 7
Relative formula mass of the compound = 278
15.8 g of $FeSO_4.7H_2O$ = 0.057 mol
5.11 g of H_2O = 0.28 mol
Therefore when 1 mol of $FeSO_4.7H_2O$ partially dehydrates, 5 mol of water are formed.
Therefore y = 7 – 5 = 2

Sheet 3

The working for questions 1 to 5 is exactly as on *Resource Sheet 1*.
1 1.3 g
2 11.25 g
3 29x/9
4 (a) 16.2 kg (b) 2.8 kg
5 (a) 19.2 g (b) 2.8 g

Sheet 3 continued

6 By inspection of the equations, it can be seen that the following molar ratios exist:
$4NH_3$:$4NO$:$4NO_2$:$2.67HNO_3$ (4 × 2/3)
Therefore molar ratio of NH_3:HNO_3 = 1:0.667 (2.67/4)
1.7 tonnes of NH_3 = 1.7/17 = 0.1 'mol'
Moles of HNO_3 produced = 0.1 × 0.667 = 0.067 mol
Therefore mass of HNO_3 produced = 4.2 tonnes

7 0.4 g of NO = 0.0133 mol
moles of NO produced per day = 0.0133 × 12 000/365 = 0.44 mol
Mass of NH_3 required = 0.44 × 4/6 × 17 = 4.98 g

8 4.2 g Fe = 0.075 mol
7.99 g Cl_2 = 0.112
Molar ratio Fe:Cl_2 = 1:1.5 i.e. 2:3
Equation is: $2Fe(s) + 3Cl_2(g) \longrightarrow 2FeCl_3(s)$

9 (a) Moles Cu = 0.05 mol, moles HNO_3 = 0.133 (b) Cu:HNO_3 = 1:2.66 i.e. 3:8
(c) $3Cu(s) + 8HNO_3(aq) \longrightarrow 3Cu(NO_3)_2(aq) + 2NO(g) + 4H_2O(l)$

10 3.14 g ethanoyl chloride = 0.04 mol
Therefore maximum yield is 0.04 × 101 = 4.04 g
%age yield = 3.21/4.04 × 100 = 79.5%

Sheet 4

1 (a) 2 mol (b) 5×10^{-3} mol (c) 0.2 mol
2 (a) 120 dm^3 (b) 72 cm^3 (c) 2400 cm^3
3 (a) 0.14 cm^3 (b) 56 cm^3 (c) 11.2 dm^3
The working for questions 4 and 5 is as on *Resource Sheet 1*.
4 1200 cm^3
5 6000 cm^3
6 80 dm^3 oxygen (10 × 8), 50 dm^3 carbon dioxide (10 × 5)
7 250 cm^3 of SO_2 will need 500 cm^3 of H_2S to react completely.
Therefore only 150 cm^3 of SO_2 will react, leaving an excess of 100 cm^3. 300 cm^3 of water vapour will be produced (2 × 150).
Therefore total volume of gas at the end = 400 cm^3
8 Volume of CO_2 formed = 50 cm^3 therefore molar ratio of C_xH_y:CO_2 = 1:5, x = 5
Moles of H_2O = 0.048/18 = 2.67×10^{-3} mol and moles of CO_2 = 50/22400 = 2.23×10^{-3} mol
Therefore molar ratio H_2O:CO_2 = 2.67:2.23 i.e. 1.2:1.0 or 6:5, y = 12

Sheet 5

1 (a) 4 M (b) 0.5 M (c) 0.0167 M
2 (a) 6×10^{-3} mol (b) 0.288 mol (c) 1.8 mol
3 (a) 9.8 g (b) 13 g (c) 207 g
4 25 cm^3 0.1M KOH = 25/1000 × 0.1 = 2.5×10^{-3} mol
Moles H_2SO_4 reacted = 1.25×10^{-3} mol
Concentration of H_2SO_4 = $1.25 \times 10^{-3} \times 1000/19.8$ = 0.063 M
5 Moles HNO_3 = 20/1000 × 1.2 = 0.024 mol
Moles CO_2 produced = 0.012 mol
Volume CO_2 = 24000 × 0.012 = 288 cm^3
6 Moles $MgCl_2$ = 10/1000 × 1.5 = 0.015 mol
Moles AgCl = 0.03 mol
Mass AgCl = 4.31 g

Sheet 5 continued

7 Moles HCl = 15.4/1000 × 0.78 = 0.012 mol
Moles $Na_2CO_3.xH_2O$ in 25 cm^3 that reacted = 6×10^{-3} mol
Therefore moles of $Na_2CO_3.xH_2O$ in 250 cm^3 = 6×10^{-2} mol
17.16 g = 6×10^{-2} mol. Mass of 1 mol = 286
i.e. Relative formula mass is 286.
Mass due to Na_2CO_3 is 106. Therefore xH_2O = 180, x = 10

8 (a) Moles $H_2O_2 = 4 \times 10^{-4}$
Moles MnO_4^- reacting = 1.6×10^{-4}
Volume MnO_4^- = $1.6 \times 10^{-4} \times 1000/0.04 = 4$ cm^3
(b) Volume of $O_2 = 4 \times 10^{-4} \times 24000 = 9.6$ cm^3

Sheet 6

1 (a) Using the expression $P_1V_1/T_1 = P_2V_2/T_2$
$70 \times 240/353 = 100 \times V_2/273$
Therefore $V_2 = 129.9$ cm^3
Using the same method: (b) 37.8 dm^3 (c) 54.77 dm^3 (d) 1700 dm^3

2 (a) Use PV = nRT
$n = 100\,000 \times 4.4 \times 10^{-3}/8.31 \times 293 = 0.18$
(b) Use the same method and n = 0.91.
(c) 22 g of CO_2 = 0.5 mol (trick question!)

3 These questions all involve the formula PV = nRT (and mol = g/M_r in part (d))
(a) 48.7 dm^3 (b) 1.55 A (c) 361 K (d) 0.345 dm^3

4 0.1 mol H_2S and 1 mol NH_3
$T_1 = T_2$
Therefore $P_1V_1/n_1 = P_2V_2/n_2$ (R cancels)
$2000 \times 10^{-6}y/0.1 = 5000 \times 10^{-6} \times P_2/1$
P_2 = 4y MPa

5 Use PV = nRT to find n = 0.068
Therefore g = 0.068 × 153 = 10.4 g

6 Use PV = nRT to find n = 0.066
Therefore M_r = 3/0.066 = 45.4

7 Moles SO_3 = 0.1 mol
$V = 0.1 \times 8.31 \times 546/1 \times 105 = 4.54 \times 10^{-3}$ m^3 (4.54 dm^3)

8 $n = 3.5 \times 105 \times 2.9 \times 10^{-3}/8.31 \times 320 = 0.38$ mol

9 $n = 1.3 \times 105 \times 1 \times 10^{-3}/8.31 \times 320 = 0.049$ mol
M_r = 1.459/0.049 = 29.8

10 $n = 0.55 \times 105 \times 0.95 \times 10^{-3}/8.31 \times 513 = 0.012$
M_r = 66.7